EFFECTS OF REDUCING THE TRANSFER ENERGY FROM 10 BEV TO 8 BEV

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As a supplement to the study of the choices of rep-rates of the booster and the main ring (FN-181) the task team, consisting of R. Billinge, T. Collins, Q. Kerns, A. Maschke, F. Shoemaker, and L. Teng, investigated the effects of reducing the transfer energy between the booster and the main ring, from 10 BeV to 8 BeV. We take as reference the case for which the rep-rate of the booster is 15 Hz and the MR pulsing time is 2.2 sec (namely the repetition period without flat-top is 3.0 sec). Again the ground rule assumed is that the design of the MR and the booster magnets shall not be affected by this change. Various considerations are given below.

1. The transverse incoherent space charge limit for the MR at 8 BeV is 0.8×10^{14} p/pulse compared to 1.0×10^{14} p/pulse at 10 BeV. Therefore, the MR will be operating closer to the space charge limit, although for the reference case the design intensity is still below the limit. Nevertheless, this consideration favors the higher transfer energy.

2. At 8 BeV injection energy into the MR the injection field is reduced from 486 G to 396 G. The change in field strength is small so that the differences in the effects on particle orbits of relative field errors due to remanent and

stray fields are not significant. Similarly the technical and economic effects of the charge on the MR power supplied are totally negligible.

3. The increase in the MR accelerating RF voltage due to the lower injection energy is again negligible. However, the lower injection energy raises the required frequency modulation of the MR RF system substantially from $\frac{\Delta f}{f} = 0.37\%$ to 0.55%. A straightforward way to obtain this increased range of frequency modulation is to add another cavity and its associated equipment and modify the ferrite tuners for all 17 cavities. The estimated increase in cost of the MR RF system is K$220.

In addition, the initial rate of frequency rise $\dot{f}$ is higher for the lower injection energy. Although not serious the higher initial transient in the servo loops due to the higher $\dot{f}$ is undesirable.

4. Lowering the final energy of the booster from 10 BeV to 8 BeV reduces the peak field from 8.90 kG to 7.26 kG in the F magnet and from 7.57 kG to 6.17 kG in the D magnet. This is advantageous for maintaining adequate good field width at the high energy end. This is especially true for the F magnet in which the good field width is slightly reduced at 10 BeV.

Lowering the final energy has a substantial effect on the magnet power supply. The cost estimate shows a reduction of K$520 in the booster power supply when the final energy is reduced to 8 BeV.

5. There is some cost saving in the booster RF system. But since the RF requirement is determined largely by the need to provide an adequately large RF bucket size to contain the momentum spread of the beam shortly after injection and not so much by the need for accelerating the beam, the reduction in the RF system is much less than that indicated by the reduction in final energy. Studies indicate that only one out of the 16 cavities can be removed. Since the booster RF cavities are installed in pairs, removing one member of a pair does not lead to a proportionate cost saving. For example, all the dc bias supplies which are arranged to power cavities in pairs will still be needed. In this case the cost saving is estimated to be no more than K$150.

6. The beam transfer between the booster and the MR which includes extraction from the booster, transport to the MR, and injection into the MR, is somewhat easier at 8 BeV. The advantage gained in handling a softer beam is partially offset by the somewhat bigger beam cross-section. The differences in both technology and cost are not significant enough to influence the consideration.

In summary, reducing the transfer energy from 10 BeV to 8 BeV can lead to a theoretical cost reduction of about

K$450. On the other hand, this gives a tighter space charge limit in the MR, hence a reduction in the ultimate intensity capability of the accelerator. Also, to make the change at this time the re-design effort involved will further reduce the already small amount of cost saving. The task team, therefore, recommends that the transfer energy between the booster and the main ring be kept at 10 BeV.